Bibliometric Analysis of Global Research on Muskmelon (*Cucumis melo* L.) Based on Web of Science

Bao-Zhong Yuan

College of Plant Science and Technology, Huazhong Agricultural University, Wuhan, Hubei, PR China, 430070

Zhi-Long Bie

College of Horticulture and Forestry, Huazhong Agricultural University, Wuhan, Hubei, PR China, 430070

Jie Sun

Library of Huazhong Agricultural University, Wuhan, Hubei, PR China, 430070

Additional index words. bibliometric analysis, muskmelon, *Cucumis melo*, VOSviewer, Web of Science

Abstract. Muskmelon is a warm season cucurbit species that belongs to family Cucurbitaceae. We analyzed 2955 papers of global research on muskmelon (*Cucumis melo* L.) based on Web of Science from 1924 to 2021. Papers were mainly written in English (2766, 93.604%), from 7883 authors, 83 countries or regions, 1697 organizations, and published in 585 journals and book series. The top five journals were *HortScience* (334, 11.303%), *Journal of the American Society for Horticultural Science* (*Proceedings of the American Society for Horticultural Science*) (117, 3.959%), *Scientia Horticulturae* (109, 3.689%), *Plant Disease* (88, 2.978%), and *Phytopathology* (84, 2.843%), each of which published more than 84 papers. The top five countries or regions were the United States, PR China, Spain, Brazil, and Japan, which each published more than 168 papers. The top six organizations were U.S. Department of Agriculture Agricultural Research Service, Agricultural Research Organization, Texas A&M University, Universitat Politècnica de Valencia, University of California–Davis and Consejo Superior de Investigaciones Científicas, each of which published more than 64 papers. The top five authors are G.D. Lester, J.D. McCreight, J. Garcia-Mas, K.M. Crosby, and T.J. Ng, who each published more than 26 papers. On the basis of the analysis of a network map of VOSviewer, there were cooperation among authors, organizations, and countries or regions. All keywords of muskmelon research were separated into eight clusters for different research topics. Visualizations offer exploratory information on the current state and indicate possible developments in the future. This work is also useful for students identifying graduate schools and researchers selecting journals.

Muskmelon (*Cucumis melo* L.) is a cultivar of *Cucumis melo* and a warm-season cucurbit species that belongs to family cucurbitaceae (Faruq et al., 2020; Jeffrey, 1980; Kirkbride, 1993). They are often readily available from the late summer to the early fall in the market. Muskmelon is enormously healthful because it is rich in ascorbic acid, carotene, folic acid, and potassium as well as several other bioactive

compounds (Thakur et al., 2019). Sweetness of the fruit, flavor or aroma, texture, and phytonutrients are the most important traits that determine consumer preference. Muskmelon varieties are mainly cultivated for their fruit, which differs in quality features such as organic acids, soluble sugars, vitamin, minerals, and sweet aromatic flavor (Kishor et al., 2021). Improvement in melon by traditional hybridization is relatively slow and is also restricted to a narrow gene pool. Biotechnological methods have been developed to increase the genetic diversity by somatic hybridization or gene transfer and to optimize conventional breeding programs through construction of a genetic map. To date, melon is an economically important fruit crop, and its production has become extremely common in China, especially under greenhouse cultivation (Zhang et al., 2020).

This study used elementary methods of bibliometrics and closely related informetrics or scientometrics, which are based on quantitative analysis and mapping of research in

scholarly literature. Bibliometrics has been adopted in horticulture research on topics such as essential oil-bearing plants exposed to the water stress (Kulak et al., 2019); grafting in horticultural plants (Belmonte-Ureña et al., 2020); scientific research on fungus *Phakopsora pachyrhizi* Sydow and Sydow affecting soybean [*Glycine max* (L.) Merrill] (Meira et al., 2020); highly cited articles in the science citation index—expanded subject category of horticulture (Kolle et al., 2017); research, innovation, and development on *Corylus avellana* (Raparelli and Lolletti, 2020); berries (Yeung et al., 2019); analysis of INRA publications on fruits and vegetables produced between 2002 and 2006 (Tatry et al., 2011); analysis of INRA scientific academic literature on fruits and vegetables for the 2000–06 period (Leiser et al., 2009); tree fruit growing in Germany (Dalla Via and Baric, 2012); trends in Mango research (Kolle et al., 2018); wine research and its relationship to wine production (Jamali et al., 2020); and wine and grape research for wine-producing and consuming countries (Glanzel and Veugelaers, 2006). This technique is also used in research related to irrigation and water use efficiency, such as soil and water conservation in the Loess Tableland-Gully Region of China (Wang et al., 2019), and advances in water use efficiency in agriculture and sustainable water use in agriculture (Velasco-Muñoz et al., 2018a, 2018b). Sun and Yuan have published some papers as rice with fertilizer based on CiteSpace (Sun and Yuan, 2019), the top papers in world rice research (Sun and Yuan, 2020a), Library and Information Science (Sun and Yuan, 2020b), water resources (Sun and Yuan, 2020c), green and sustainable science and technology (Yuan and Sun, 2019), agronomy (Sun and Yuan, 2021), and scientific research on maize or corn (Yuan and Sun, 2020a, 2020b).

The aim of the study was to assess global research publications on muskmelon (*Cucumis melo* L.) based on Web of Science (WoS) by bibliometric science mapping and visualization tools. We assessed the scatter of publications in citation databases, classification of topics, and progress over the years. Country input and author collaboration (coauthorship) are addressed. Special attention is dedicated to research topics and research fronts.

Data and Methodology

Web of Science. Clarivate Analytics' WoS is the world's leading scientific citation search and analytical information platform and the one of the world's largest and most comprehensive academic information resources covering more than 12,361 core academic journals. The publication counts from the WoS Core Collection were derived from the following databases: The Science Citation Index-Expanded (SCIE)—1900–present, Social Science Citation Index (SSCI)—1900–present, Conference Proceeding Citation Index-Science (CPCI-S)—2015–present, Conference Proceedings Citation Index—Social Science & Humanities (CPCI-SSH)—2015–present, Current Chemical Reactions

Received for publication 10 March 2021. Accepted for publication 3 May 2021.

Published online 18 June 2021.

This work was supported by China Agriculture Research System of MOF and MARA (CARS-25) and the Innovative Research Group Project of Natural Science Foundation of Hubei Province, China (2019CFA017).

B.-Z. Yuan and Z.-L. Bie are the corresponding authors. E-mail: yuanbz@mail.hzau.edu.cn or biezl@mail.hzau.edu.cn.

This is an open access article distributed under the CC BY-NC-ND license (<https://creativecommons.org/licenses/by-nc-nd/4.0/>).

(CCR-EXPANDED)—1985—present, Index Chemicus (IC)—1993—present.

Data collection and analysis. This study surveyed papers in WoS Core Collection (retrieval data last updated: 15 Feb. 2021). We used the keywords in the topic, with the query Topic = (“Muskmelon” OR “*Cucumis melo* L.”)

There are 2955 papers from the WoS Core Collection. Full record and cited references of the included papers were extracted at other reference software file formats and imported into VOSviewer (version 1.6.16, 2020, Leiden University, Leiden, The Netherlands) for further citation analysis. The impact factors (IF 2019 and IF 5 year) were taken from the Journal Citation Report (JCR 2019) published in 2020, which had the latest data available.

VOSviewer. Visualizations (network and overlay) using program VOSviewer are conducted on WoS data to determine co-occurrence and clusters of connected publications, country input and author collaboration (coauthorship) as well as clusters of interrelated research topics (text data). In this work, we used VOSviewer to indicate the international collaboration between the authors, organizations, countries, and the research trends through all keywords (Van Eck and Waltman, 2010). In this article, default parameters values of the VOSviewer were usually used in the analysis. Items are represented by a label and a circle. The size of circles reflects the weight of an item. Some items are not displayed to avoid overlap. The colors in network visualization (text maps) represent clusters of similar items as calculated by the program. Distance between the items indicates the strength of relationships.

Results and Discussion

Document type and language of publication. On the basis of Clarivate Analytics’ WoS Index, the 2955 papers were SCIE (2902), CPCI-S (109), SSCI (11), IC (4), Arts and Humanities Citation Index (4), and Book Citation Index–Science (1). The first paper titled of “A Seedless Muskmelon,” written by L.J. Cole (1924), was published in 1924 in *Journal of Heredity* (15:219–219).

The published document types and languages are described in Table 1. Among the document types, there were articles (2536, 85.821%), meeting abstracts (188, 6.362%), notes (94, 3.181%), proceedings papers (84, 2.843%), reviews (53, 1.794%), and editorial material (14, 0.474%), for example. Most of the articles were published in English (2766, 93.604%), and then in Portuguese (92, 3.113%), Japanese (29, 0.981%), French (23, 0.778%), Spanish (19, 0.643%), Chinese (11, 0.372%), Korean (10, 0.338%), and German (2, 0.068%). English was dominant language from the WoS; scholars tended to publish their articles in English because they want them to be widely accepted. Moreover, most published documents were in the form of original research articles written in English (Khan et al., 2020).

Table 1. Document type and language of publication of muskmelon research.

Rank	Document type			Language		
	Document type	Records	% Total papers	Language	Records	% Total papers
1	Article	2,536	85.821	English	2,766	93.604
2	Meeting abstract	188	6.362	Portuguese	92	3.113
3	Note	94	3.181	Japanese	29	0.981
4	Proceedings paper	84	2.843	French	23	0.778
5	Review	53	1.794	Spanish	19	0.643
6	Editorial material	14	0.474	Chinese	11	0.372
7	Early access	6	0.203	Korean	10	0.338
8	News item	6	0.203	German	2	0.068
9	Correction	5	0.169	Italian	1	0.034
10	Letter	5	0.169	Polish	1	0.034
11	Correction addition	2	0.068	Turkish	1	0.034
12	Book chapter	1	0.034			
13	Data paper	1	0.034			

Publication output. With the aim of knowing the trend in muskmelon research, a total of 2955 publications were obtained from the online version of WoS database from 1924 to 2021 (Fig. 1). The most papers (145) were published in 2019. In general, the quantity of muskmelon research literature began increasing after 1971. There are 41, 132, 257, 566, 715 and 1078 papers published during the periods of 1960–69, 1970–79, 1980–89, 1990–99, 2000–09, and 2010–19, respectively.

WoS categories and research areas. For muskmelon research from 1924 to the present, there are 93 WoS subject categories in the science edition (254 categories) and 60 research areas. Table 2 shows the top 20 WoS categories and top 20 research areas on the subject of muskmelon research. The top five WoS categories include Plant Sciences (1046, 35.398%), Horticulture (958, 32.42%), Agronomy (494, 16.717%), Food Science Technology (281, 9.509%), and Agriculture Multidisciplinary (216, 7.31%). The top five research areas include Agriculture (1519, 51.404%), Plant Sciences (1046, 35.398%), Food Science Technology (281, 9.509%), Biotechnology Applied Microbiology (154, 5.212%), and Chemistry (152, 5.144%). The journals or papers either classified in two or more categories in the WoS shows the

multidisciplinary character of this research field (Elango and Ho, 2017, 2018). Documents are mapped to one or several research areas in WoS. Areas are assigned to publications and then mapped to each document (paper) in a publication. Therefore, publications can be mapped to several areas. In WoS, publications are also mapped to WoS categories which are more detailed than areas (Stopar et al., 2019).

Core journals. Based on JCR 2019 data (published in 2020), there were 585 journals and book series of the WoS categories for muskmelon research from 1924 to 2021. Among these, the 11 book series includes *Acta Horticulturae*, *AIP Conference Proceedings*, *ACS Symposium Series*, *AER Advances in Engineering Research*, *IOP Conference Series Earth and Environmental Science*, for example. The top 22 journals with IF (IF 2019 and IF 5 years), rank, and quartile in category are displayed in Table 3. Each journal contains more than 23 published papers. In general, we combined the current and formerly journal title (Table 3), but the total number of journals in the WoS were calculated separately.

The top 5, top 10, top 15, and top 20 journals published approximately 24.467%, 30.897%, 36.277%, and 40.406% of the total papers, respectively. The top five journals are

Fig. 1. Number of published papers of muskmelon research from 1924 to 2021.

Table 2. Relevance of the 2955 total melon papers published from 1924 through 2021 to the top 20 Web of Science (WoS) categories and research areas; some papers were relevant to more than one category or area.

Rank	WoS categories			Research areas		
	Categories	No. papers	% Total papers	Areas	No. papers	% Total papers
1	Plant sciences	1,046	35.398	Agriculture	1,519	51.404
2	Horticulture	958	32.42	Plant sciences	1,046	35.398
3	Agronomy	494	16.717	Food science technology	281	9.509
4	Food science technology	281	9.509	Biotechnology applied microbiology	154	5.212
5	Agriculture multidisciplinary	216	7.31	Chemistry	152	5.144
6	Biotechnology applied microbiology	154	5.212	Biochemistry molecular biology	128	4.332
7	Genetics heredity	120	4.061	Genetics heredity	120	4.061
8	Biochemistry molecular biology	119	4.027	Entomology	107	3.621
9	Entomology	107	3.621	Science technology other topics	75	2.538
10	Chemistry applied	103	3.486	Environmental sciences ecology	61	2.064
11	Multidisciplinary sciences	69	2.335	Life sciences biomedicine other topics	41	1.387
12	Soil science	60	2.03	Nutrition dietetics	38	1.286
13	Environmental sciences	48	1.624	Engineering	34	1.151
14	Biology	41	1.387	Cell biology	28	0.948
15	Nutrition dietetics	38	1.286	Water resources	28	0.948
16	Agricultural engineering	36	1.218	Microbiology	25	0.846
17	Chemistry analytical	33	1.117	Evolutionary biology	17	0.575
18	Cell biology	28	0.948	Pharmacology pharmacy	17	0.575
19	Water resources	28	0.948	Virology	15	0.508
20	Microbiology	25	0.846	Mycology	12	0.406

HortScience (334, 11.303%), *Journal of the American Society for Horticultural Science* (*Proceedings of the American Society for Horticultural Science*; 117, 3.959%), *Scientia Horticulturae* (109, 3.689%), *Plant Disease* (88, 2.978%), and *Phytopathology* (84, 2.843%), each of which published more than 84 papers. On the basis of the results shown in Table 3, among the top 22 journals, 11 were in quartile

1, six were in quartile 2, four were in quartile 3 in category, and one was in a book series. White-Gibson et al. (2019) have also demonstrated the importance of publishing articles in the English language in a high IF journals. Citation analysis is not a measurement of scientific quality, but it is reflective of the importance.

Author coauthorship analysis. In general, internationally collaborative articles had the

highest visibility and scientific impact, followed by interinstitutional collaborative articles, single-country articles, and single-author articles, respectively (Wambu and Ho, 2016). According to the published data analysis results, 7883 authors had 2955 publications, and among these, 253 authors met the threshold of five publications, but only 73 authors were connected with each other. The network of authorship in the field of muskmelon research is represented in Fig. 2; the size of the circles reflects the total number of records. Authors in the same cluster usually suggested that they studied in a similar field or worked at the same institute or had close cooperation with each other.

Details on author information of published articles on muskmelon from 1924 to 2021, along with citation, average citations, organization, and countries are provided in Table 4. According to our analysis, the top 21 authors published more than 19 papers. We combined the same author with different spellings, but the total number of authors were calculated separately. The top five authors were Gene E. Lester, James D. McCreight, Jordi Garcia-Mas, Kevin M. Crosby, and T.J. Ng., each of whom published more than 26 papers. The top 21 authors were mainly from the United States, Israel, and Spain. There were 10 authors from the United States; organizations included the U.S. Department of Agriculture Agricultural Research Service (USDA ARS), Texas A&M University System, University of Wisconsin System, University of California Berkeley, Virginia Polytechnic Institute & State University and University of California–Davis; four authors from Israel were from the Agricultural Research Organization (ARO), and Bar Ilan University; four authors from Spain were from the University of Barcelona and Universitat Politècnica de Valencia; one author was from the INRAE Genet & Améliorat Fruits & Légumes of France; one author was from Universidade Federal Rural do Semi-Arido of Brazil; one author was from the Singapore Institute of Manufacturing Technology. The five authors with the highest average citations per paper were N. Katzir, Antonio J. Monforte, Jordi Garcia-Mas, M. Pitrat, and Jack E. Staub.

Countries/regions coauthorship analysis.

There were 83 countries or regions that contributed 2955 papers in muskmelon research. Table 5 lists the top 20 countries or regions that published more than 25 papers and also shows the cluster, total link strength, citations, and average citations. Among 20 countries, the United States, PR China, Spain, Brazil, and Japan were the major article contributors. For average number of citations, England, Germany, France, Israel, and Greece had the higher citations per paper.

We developed the coauthorship network map using VOSviewer (Fig. 3). Forty-three countries or regions met the requirement threshold of five. The size of circles in Fig. 3 reflects the total number of records, and the distance between countries indicates the strength of relationships. The VOSviewer divided these circles into nine clusters. The different colors represent the different clusters formed by sets of countries. Distance

Table 3. Top 22 journals on muskmelon research indexed in the Web of Science (WoS).

Rank	Journal	% Total			IF 2019	IF 5 yr	QC
		Papers	papers				
1	<i>HortScience</i>	334	11.303	1.102	1.19	Q3	
2	<i>Journal of the American Society for Horticultural Science (Proceedings of the American Society for Horticultural Science)</i>	117	3.959	0.952	1.378	Q3	
3	<i>Scientia Horticulturae</i>	109	3.689	2.769	2.844	Q1	
4	<i>Plant Disease</i>	88	2.978	3.809	3.95	Q1	
5	<i>Phytopathology</i>	84	2.843	3.234	3.492	Q1	
6	<i>Euphytica</i>	43	1.455	1.614	1.883	Q2	
7	<i>Horticulture Journal (Journal of the Japanese Society for Horticultural Science)</i>	40	1.354	1.176	1.157	Q2	
8	<i>Journal of Horticultural Science Biotechnology (Journal of Horticultural Science)</i>	39	1.320	1.16	1.191	Q2	
9	<i>Plant Physiology</i>	37	1.252	6.902	7.52	Q1	
10	<i>Journal of Agricultural and Food Chemistry</i>	35	1.184	4.192	4.29	Q1	
11	<i>Theoretical and Applied Genetics</i>	34	1.151	4.439	4.603	Q1	
12	<i>Journal of Plant Nutrition</i>	34	1.151	1.132	1.143	Q3	
13	<i>Postharvest Biology and Technology</i>	32	1.083	4.303	4.765	Q1	
14	<i>Acta Horticulturae</i>	31	1.049	—	—	—	
15	<i>European Journal of Plant Pathology</i>	28	0.948	1.582	1.732	Q2	
16	<i>Plant Cell Tissue and Organ Culture</i>	27	0.914	2.196	2.329	Q2	
17	<i>Journal of the Science of Food and Agriculture</i>	24	0.812	2.614	2.945	Q1	
18	<i>Journal of Experimental Botany</i>	24	0.812	5.908	7.011	Q1	
19	<i>Journal of Economic Entomology</i>	24	0.812	1.938	2.071	Q1	
20	<i>PloS One</i>	23	0.778	3.74	3.227	Q2	
21	<i>HortTechnology</i>	23	0.778	0.668	0.729	Q3	
22	<i>Food Chemistry</i>	23	0.778	6.306	6.219	Q1	

QC = quartile in category. Data were from the 2020 edition of *Journal Citation Reports*.

Fig. 2. Network visualization maps of authors in muskmelon research from 1924 to 2021.

between the countries indicates the strength of the relationships.

As shown in Fig. 3, the first cluster consisted of nine countries or regions (red) including the United States, Japan, South

Korea, Malaysia, Thailand, Indonesia, Taiwan, Poland, and Bangladesh. The second cluster consisted of seven countries or regions (green) including Spain, Mexico, Tunisia, Chile, Belgium, Morocco, and Portugal. The

third cluster consisted of six countries (dark blue) including PR China, India, Canada, Pakistan, Egypt, and Saudi Arabia. The fourth cluster consisted of five countries and regions (yellow color) including Italy, England, Greece, Cyprus, and Denmark. The fifth cluster consisted of four countries (violet) including Brazil, France, Argentina, and Venezuela. The sixth cluster consisted of four countries (light) including Turkey, Iran, Hungary, and Switzerland. The seventh cluster consisted of three countries (orange) including Australia, the Netherlands, and Oman. The eighth cluster consisted of three countries (brown) including Germany, Czech Republic, and Sudan. The ninth cluster consisted of two countries (pink) including Israel and Austria. More cooperation could bring more advances in scientific research. Today, increasing international exchange has promoted academic communications (Tang et al., 2018).

Organization coauthorship analysis. According to the publication data, it was revealed that 1697 organizations had 2955 publications. Organization coauthorship analysis reflects the degree of communication between institutions as well as the influential institutions in this field (Reyes-Gonzalez et al., 2016). Table 6 represents the top 22 organizations and institutions ranked by the number of total publications (more than 25 papers), the total link strength, citations, average citations, and country. We combined the same organization with different spelling, but the total organization numbers in the WoS were calculated separately. These 22 organizations were mainly based in the United States (12 organizations), China (three organizations), Spain (two organizations), Brazil (two organizations), Israel (two organization),

Table 4. The top 21 most prolific authors published papers in the field of muskmelon research from 1924 to 2021.

Rank	Author	Papers	Citations	Avg citations	Organization	Country
1	Lester, Gene E. (Lester, Gene; Lester, GE; Lester, G)	49	1,217	24.84	USDA ARS	USA
2	McCreight, James D. (McCreight, J.D.; McCreight, JD)	40	765	19.13	USDA ARS	USA
3	Garcia-Mas, Jordi (Garcia-Mas, J)	28	1,195	42.68	University of Barcelona	Spain
4	Crosby, Kevin M. (Crosby, Kevin)	28	257	9.18	Texas A&M University	USA
5	Ng, TJ	26	143	5.50	Singapore Institute of Manufacturing Technology	Singapore
6	Staub, Jack E. (Staub, J.E.; Staub, JE)	24	850	35.42	University of Wisconsin	USA
7	Pico, Belen (Pico, B)	24	461	19.21	UPV	Spain
8	Bruton, BD	23	376	16.35	USDA ARS	USA
9	De Medeiros, Jose Francismar (De Medeiros, Jose F)	23	114	4.96	Universidade Federal Rural do Semi-Arido	Brazil
10	Katzir, Nurit (Katzir, N)	22	1,389	63.14	ARO	Israel
11	Edelstein, Menahem (Edelstein, M)	22	509	23.14	ARO	Israel
12	Nugent, PE	22	165	7.50	UC Berkeley	USA
13	Monforte, Antonio J. (Monforte, AJ)	21	1,000	47.62	UPV	Spain
14	Pitrat, M	21	875	41.67	INRAE Genet & Ameliorat Fruits & Legumes	France
15	Welbaum, Gregory E. (Welbaum, GE)	21	524	24.95	Virginia Polytechnic Institute & State University	USA
16	Nuez, Fernando (Nuez, F)	21	442	21.05	UPV	Spain
17	Bohn, GW	20	425	21.25	USDA ARS	USA
18	Nerson, H	20	166	8.30	ARO	Israel
19	Zink, FW	20	166	8.30	UC Davis	USA
20	Cohen, Y	19	475	25.00	Bar Ilan University	Israel
21	Jifon, John L. (Jifon, John)	19	89	4.68	Texas A&M University	USA

ARO = Agricultural Research Organization; UC = University of California; UPV = Universitat Politècnica de València; USDA ARS = U.S. Department of Agriculture Agricultural Research Service.

Table 5. Top 20 countries or regions publishing papers in the field of muskmelon research from 1924 to 2021.

Rank	Countries/Regions	Records	Cluster	Total link strength	Citations	Avg citations
1	USA	808	1	213	17,901	22.15
2	PR China	322	3	78	3,751	11.65
3	Spain	274	2	122	6,898	25.18
4	Brazil	200	5	27	1,297	6.49
5	Japan	168	1	43	2,917	17.36
6	Israel	153	9	82	5,076	33.18
7	India	124	3	24	1,132	9.13
8	Turkey	102	6	31	1,515	14.85
9	France	95	5	70	3,237	34.07
10	Italy	90	4	43	2,040	22.67
11	South Korea	75	1	23	1,401	18.68
12	Canada	45	3	24	978	21.73
13	Iran	45	6	16	338	7.51
14	Mexico	42	2	19	350	8.33
15	Australia	27	7	13	722	26.74
16	England	26	4	22	1,019	39.19
17	Malaysia	26	1	9	312	12.00
18	Pakistan	26	3	18	398	15.31
19	Germany	25	8	23	918	36.72
20	Greece	25	4	13	705	28.20

Fig. 3. The country coauthorship network of muskmelon research from 1924 to 2021 with 43 circles and nine clusters.

Table 6. Top 22 organizations publishing papers in the field of muskmelon research from 1924 to 2021.

Rank	Organizations	Records	Total link strength	Citations	Avg citations	Country
1	U.S. Department of Agriculture Agricultural Research Service	187	135	5,748	33.74	USA
2	Agricultural Research Organization	94	81	3,277	34.86	Israel
3	Texas A&M University	78	29	871	11.17	USA
4	Universitat Politècnica de Valencia	74	65	1,852	25.03	Spain
5	University of California Davis	64	27	1,487	23.23	USA
6	Consejo Superior de Investigaciones Científicas	64	42	2,139	33.42	Spain
7	University Florida	55	22	740	13.45	USA
8	Universidade Federal Rural do Semi-Arido	47	34	200	4.26	Brazil
9	Institut National de la Recherche Agronomique	47	16	1,745	37.13	France
10	Cornell University	46	33	2,143	46.59	USA
11	Purdue University	44	14	356	8.09	USA
12	Hebrew University Jerusalem	35	34	1,507	43.06	Israel
13	University Maryland	33	24	320	9.70	USA
14	Ministry of Agriculture	32	31	334	10.44	China
15	University Wisconsin	31	35	1,411	45.52	USA
16	Gansu Agriculture University	30	15	545	18.17	China
17	Clemson University	28	22	506	18.07	USA
18	Iowa State University	28	11	200	7.14	USA
19	Michigan State University	27	12	553	20.48	USA
20	Universidade Federal do Ceara	27	23	223	8.26	Brazil
21	Northeast Agriculture University	25	22	86	3.44	China
22	University of California, Riverside	25	21	642	25.68	USA

and France (one organization). Furthermore, the organizations of USDA ARS, Agricultural Research Organization (ARO), Texas A&M University, Universitat Politècnica de Valencia, University of California–Davis and Consejo Superior de Investigaciones Científicas were popular based on the contribution of articles more than 64 papers each. Similarly, with regard to citations, Cornell University, the University of Wisconsin, Hebrew University Jerusalem, Institut National de la Recherche Agronomique, and ARO showed the highest average citations with more than 34.86 citations per paper.

Among the total 1697 organizations, 181 met the minimum threshold of five, but 169 organizations were connected to each other (Fig. 4). The VOSviewer software divided these 169 institutes into 18 clusters with different colors. Within the context of network formation, organizations tend to form bonds with other institutions in the same region. Geographic localization is an important factor for partnership and joint ventures. Therefore, there is a heavy presence of intrainstitutional relationships within the scientific network on publications.

All keywords cooccurrence analysis. Figure 5 shows the network map that links all keywords to the entire sample of the articles analyzed. Among all 8655 keywords, only 889 met the threshold level of more than five times included in the map. There are eight main clusters that represent different viewpoints on muskmelon research (Fig. 5). The top 20 cooccurrence keywords were muskmelon, *Cucumis melo*, melon, growth, *Cucumis melo* L., yield, quality, plants, resistance, identification, fruit, cantaloupe, tomato, *Cucumis-melo*, *Cucumis-melo* L., expression, watermelon, storage, disease, and ethylene.

The same data were then arranged by a period of muskmelon research as overlay map (Fig. 6). Blue colors indicate earlier research topics, whereas yellow and green colors indicate more recent topics of interest. The blue-colored topics do not indicate that there is no longer research work on that topics. Rather, it usually indicates that, on average, this topic was intensely investigated earlier and attention has shifted toward other topics. For example, the circle for ethylene, acid invertase, *cucumis-melo* L. and somatic embryogenesis are represented in dark blue. Perhaps these terms are now so general that they are no longer extensively used as keywords. Yellow and green circles present those research fronts. For example, growth and fruit quality at left in Fig. 5 can be observed in Fig. 6 with yellow circles or shallow-green in the same position.

Visualization conducted on large datasets (big data) offer exploratory information on the current state in a scientific field or discipline and indicate possible future developments. Here, the top 20 keywords are list and ranked in each cluster.

The first cluster (red) is focused on biological-control disease management of muskmelon and includes keywords such as muskmelon, watermelon, disease, cucumber, soil, cucurbits, management, nitrogen, wilt,

Fig. 4. The organizations coauthorship network of muskmelon research from 1924 to 2021.

biological control, f-sp melonis, fungi, root rot, vine decline, fusarium wilt, citrullus lanatus, colonization, cotton, and pathogenicity.

The second cluster (green) represents the genetic diversity and disease resistance of the *Cucumis melo* and includes keywords such as *Cucumis melo*, melon, resistance, identification, *Cucumis-melo* L., cultivars, *cucurbitaceae*, inheritance, diversity, genetic diversity, disease resistance, markers, powdery mildew, RAPD, germplasm, genes, DNA, linkage map, sequence, and evolution.

The third cluster (blue) is focused on fruit quality, and include keywords such as quality, fruit, cantaloupe, storage, *Cucumis melo* L., acid, vegetables, fruits, shelf life, honeydew, beta-carotene, flavor, firmness, maturity, aroma, color, antioxidant activity, postharvest, carotenoids, and system.

The fourth cluster (yellow) represents ethylene metabolism gene expression in *Cucumis melo* L., and keywords include as tomato, *Cucumis-melo* L., expression, ethylene, metabolism, gene, leaves, plant, arabidopsis, arabidopsis-thaliana, biosynthesis, tomato fruit, protein, purification, transport, proteins, sugar, melon (*Cucumis melo* L.), fruit ripening, and abscisic acid.

The fifth cluster (violet) is focused on stresses affecting plants growth and yield and includes keywords such as growth, *Cucumis melo* L., yield, plants, stress, accumulation, salinity, fruit-quality, salt tolerance, responses, tolerance, *Cucumis-melo* L., fruit quality, irrigation, photosynthesis, water, oxidative stress, grafting, salt stress, and model.

The sixth cluster (shallow blue) is focused on plant regeneration and somatic

embryogenesis. Keywords are ranked as somatic embryogenesis, plant regeneration, induction, regeneration, pollination, in vitro, transformation, explants, organogenesis, cotyledons, agrobacterium-mediated transformation, leaf, shoot regeneration, culture, cells, *Sativus* L., pumpkin, cotyledon, genotype, and tissue cultures, for example.

The seventh cluster (orange) is focused on temperature affecting muskmelon fruit seed germination, and keywords include temperature, muskmelon fruit, germination, water relations, acid invertase, enzymes, sucrose, maturation, *Cucumis*, sugar accumulation, fruit development, seed, sucrose-phosphate synthase, invertase, seeds, seed development, lettuce, abscisic acid, CPPU, and survival, for example.

The eighth cluster (crown) has only one keyword, nanoparticles, in the upper left corner.

Top papers based on Essential Science Indicators. Top papers are the sum of hot papers and highly cited papers, based on Clarivate Analytics' Essential Science Indicators (ESI). A highly cited paper is a one that belongs to the top 1% of papers in a research field published in a specified year. The 1% is determined by the highly cited threshold calculated for the research field in the specified year. A hot paper is a one published in the past 2 years that received a number of citations in the most recent 2-month period that places it in the top 0.1% of papers in the same field. Here, the ESI database has been updated as of 21 Jan. 2021, and data cover a 10-year and 10-month period: 1 Jan. 2010 to 31 Oct. 2020.

On the basis of ESI database, there are three highly cited papers and no hot papers. The three top papers were published in *Phytochemistry*, *BMC Plant Biology*, and *Plant Physiology and Biochemistry* in 2017, 2019, and 2020, respectively (Table 7).

The most frequently cited articles. Citation analysis has been employed as a supplementary index to determine the impact of scientific studies and to identify studies, researchers, and the most renowned institutions dealing with the theme. Although a great many articles have been published, a relatively small number of individuals account for a large proportion of the citations within the period. The annual citations of the eight papers showed an increasing trend after year of publication (Fig. 7). Here, the total citations for the most frequently cited articles was greater than 284 times. The time dependence of a single paper is called its history. In the first year (year zero here), generally the articles have fewer citations because it is the year of publication. In Fig. 7, it can be seen that the citation per year of the papers increased up to 2020, but the increase rate was different each year. Among eight articles, the highest average citation per year (43.11, blue) was observed for an article by Kloepper et al. (2004) published in *Phytopathology* (Fig. 7); the other seven papers were written by McDonald (1999), Lelievre et al. (1997), Garcia-Mas et al. (2012), Choudhary and Johri (2009), Hubbard et al. (1989), Turgeon and Wolf (2009), and Miron and Schaffer (1991).

Fig. 5. VOSviewer co-occurrence network visualization mapping of most frequent all keywords (minimum of five occurrences) in muskmelon research from 1924 to 2021.

Fig. 6. VOSviewer co-occurrence overlay visualization mapping of most frequent all keywords (minimum of five occurrences) in muskmelon research from 1924 to 2021.

Fig. 7. Comparison of the citations per year of the top eight papers from their initial publications to 15 Feb. 2021.

An increase in the number of cited references indicates that there are more citing or cited publications. The number of citations to a paper is considered a good quantitative measure of a paper's impact. The *h*-index was initially proposed as a measure of a researcher's scientific output based on counting the number

of publications (N) by that researcher cited N or more times (Hirsch, 2005). For the total 2955 papers, the *h*-index is 85, and the average citation per item is 17.72.

Conclusions

This study analyzed 2955 papers of global research on muskmelon (*Cucumis melo* L.) based on WoS from 1924 to 2021. Papers were mainly written in English, by 7883 authors, from 83 countries or territories, from 1697 organizations, and were published in 585 journals and book series. The top five journals were *HortScience*, *Journal of the American Society for Horticultural Science*,

Scientia Horticulturae, *Plant Disease*, and *Phytopathology*. Top five countries and regions were the United States, PR China, Spain, Brazil, and Japan. The top six organizations were USDA ARS, ARO, Texas A&M University, Universitat Politècnica de València, University of California–Davis, and Consejo Superior de Investigaciones Científicas. The top five authors are Gene E. Lester, James D. McCreight, Jordi Garcia-Mas, Kevin M. Crosby, and T.J. Ng. All keywords of the muskmelon research were separated into eight clusters for different research topic. This work is useful for students identifying graduate schools and researchers selecting journals.

Literature Cited

- Belmonte-Ureña, L.J., J.A. Garrido-Cardenas, and F. Camacho-Ferre. 2020. Analysis of world research on grafting in horticultural plants. *HortScience* 55(1):112–120, doi: <https://doi.org/10.21273/HORTSCI14533-19>.
- Choudhary, D.K. and B.N. Johri. 2009. Interactions of *Bacillus* spp. and plants- With special reference to induced systemic resistance (ISR). *Microbiol. Res.* 164(5):493–513, doi: <https://doi.org/10.1016/j.micres.2008.08.007>.
- Cole, L.J. 1924. A seedless muskmelon. *J. Hered.* 15:219, doi: <https://doi.org/10.1093/oxfordjournals.jhered.a102452>.
- Dalla Via, J. and S. Baric. 2012. Tree fruit growing-research and production in Germany: A statistical and bibliometric analysis of the period 1950–2010. *Erwerbs-Obstbau* 54(1):11–30, doi: <https://doi.org/10.1007/s10341-011-0155-2>.
- Elango, B. and Y.S. Ho. 2017. A bibliometric analysis of highly cited papers from India in Science Citation Index Expanded. *Curr. Sci.* 112(8): 1653–1658, doi: <https://doi.org/10.18520/cs/v112/i08/1653-1658>.
- Elango, B. and Y.S. Ho. 2018. Top-cited articles in the field of triology: A bibliometric analysis. *COLLNET J. Scientometr. Inf. Manage.* 12(2):289–307, doi: <https://doi.org/10.1080/09737766.2018.1529125>.
- Farcuh, M., B. Copes, G. Le-Navenec, J. Marroquin, D. Cantu, K.J. Bradford, J.X. Guinard, and A. Van Deynze. 2020. Sensory, physicochemical and volatile compound analysis of short and long shelf-life melon (*Cucumis melo* L.) genotypes at harvest and after postharvest storage. *Food Chem. X* 8:100107, doi: <https://doi.org/10.1016/j.fochx.2020.100107>.
- Garcia-Mas, J., A. Benjak, W. Sanseverino, M. Bourgeois, G. Mir, V.M. Gonzalez, E. Henaff, F. Camara, L. Cozzuto, E. Lowy, T. Alioto, S. Capella-Gutierrez, J. Blanca, J. Canizares, P. Ziarso, D. Gonzalez-Ibeas, L. Rodriguez-Moreno, M. Droege, L. Du, M. Alvarez-Tejedo, B. Lorente-Galdos, M. Mele, L.M. Yang, Y.Q. Weng, A. Navarro, T. Marques-Bonet, M.A. Aranda, F. Nuez, B. Pico, T. Gabaldon, G. Roma, R. Guigo, J.M. Casacuberta, P. Arus, and P. Puigdomenech. 2012. The genome of melon (*Cucumis melo* L.). *Proc. Natl. Acad. Sci. USA* 109(29):11872–11877, doi: <https://doi.org/10.1073/pnas.1205415109>.
- Glanzel, W. and R. Veugelers. 2006. Science for wine: A bibliometric assessment of wine and grape research for wine-producing and consuming countries. *Amer. J. Enol. Viticult.* 57(1): 23–32.
- Hirsch, J.E. 2005. An index to quantify an individual's scientific research output. *Proc. Natl. Acad. Sci. USA* 102(46):16569–16572, doi: <https://doi.org/10.1073/pnas.0507655102>.

- Hubbard, N.L., S.C. Huber, and D.M. Pharr. 1989. Sucrose phosphate synthase and acid invertase as determinants of sucrose concentration in developing muskmelon (*Cucumis-melo* L.) fruits. *Plant Physiol.* 91(4):1527–1534, doi: <https://doi.org/10.1104/pp.91.4.1527>.
- Jamali, H.R., C.C. Steel, and E. Mohammadi. 2020. Wine research and its relationship with wine production: A scientometric analysis of global trends. *Austral. J. Grape Wine Res.* 26(2):130–138, doi: <https://doi.org/10.1111/ajgw.12422>.
- Jeffrey, C. 1980. A review of the Cucurbitaceae. *Bot. J. Linn. Soc.* 81(3):233–247, doi: <https://doi.org/10.1111/j.1095-8339.1980.tb01676.x>.
- Jin, X.Q., T. Liu, J.J. Xu, Z.X. Gao, and X.H. Hu. 2019. Exogenous GABA enhances muskmelon tolerance to salinity-alkalinity stress by regulating redox balance and chlorophyll biosynthesis. *BMC Plant Biol.* 19:48, doi: <https://doi.org/10.1186/s12870-019-1660-y>.
- Kaya, C., M. Ashraf, M.N. Alyemeni, and P. Ahmad. 2020. The role of endogenous nitric oxide in salicylic acid-induced up-regulation of ascorbate-glutathione cycle involved in salinity tolerance of pepper (*Capsicum annuum* L.) plants. *Plant Physiol. Biochem.* 147:10–20, doi: <https://doi.org/10.1016/j.plaphy.2019.11.040>.
- Khan, A., D. Khan, and F. Akbar. 2020. Bibliometric analysis of publications on research into cotton leaf curl disease. *Discoveries (Craiova)* 8(2):E109, doi: <https://doi.org/10.15190/d.20.2.6>.
- Kirkbride, J.H.J. 1993. *Biosystematic monograph of the genus Cucumis (Cucurbitaceae): Botanical identification of cucumbers and melons.* Parkway Publishers, Boone, NC.
- Kishor, D.S., Y. Noh, W.H. Song, G.P. Lee, Y. Park, J.K. Jung, E.J. Shim, S.C. Sim, and S.M. Chung. 2021. SNP marker assay and candidate gene identification for sex expression viagenotyping-by-sequencing-based genome-wide associations (GWAS) analyses in Oriental melon (*Cucumis melo* L. var. *makuwa*). *Scientia Hort.* 276:109711, doi: <https://doi.org/10.1016/j.scienta.2020.109711>.
- Kloepper, J.W., C.M. Ryu, and S.A. Zhang. 2004. Induced systemic resistance and promotion of plant growth by *Bacillus* spp. *Phytopathology* 94(11):1259–1266, doi: <https://doi.org/10.1094/PHYTO.2004.94.11.1259>.
- Kolle, S.R., T.H. Shankarappa, and Y.S. Ho. 2017. Highly cited articles in science citation index expanded—subject category of horticulture: A bibliometric analysis. *Erwerbs-Obstbau* 59(2): 133–145, doi: <https://doi.org/10.1007/s10341-016-0308-4>.
- Kolle, S.R., T.H. Shankarappa, and T.B.M. Reddy. 2018. Trends in Mango research as seen through Science Citation Expanded Index of Web of Science. *Erwerbs-Obstbau* 60(3):261–270, doi: <https://doi.org/10.1007/s10341-018-0367-9>.
- Kulak, M., A. Ozkan, and B. Recep. 2019. A bibliometric analysis of the essential oil-bearing plants exposed to the water stress: How long way we have come and how much further? *Scientia Hort.* 246:418–436, doi: <https://doi.org/10.1016/j.scienta.2018.11.031>.
- Leiser, H., P. Aventurier, D. Fournier, F. Dosba, and B. Jeannequin. 2009. Tools for producing indicators from a bibliometric study of scientific production: The case of fruit and vegetable publications by the French National Institute for Agricultural Research (INRA). *Fruits* 64(5):305–312, doi: <https://doi.org/10.1051/fruits/2009025>.
- Lelievre, J.M., A. Latche, B. Jones, M. Bouzayen, and J.C. Pech. 1997. Ethylene and fruit ripening. *Physiol. Plant.* 101(4):727–739, doi: <https://doi.org/10.1111/j.1399-3054.1997.tb01057.x>.
- Mansour, M.M.F. and E.F. Ali. 2017. Evaluation of proline functions in saline conditions. *Phytochemistry* 140:52–68, doi: <https://doi.org/10.1016/j.phytochem.2017.04.016>.
- McDonald, M.B. 1999. Seed deterioration: Physiology, repair and assessment. *Seed Sci. Technol.* 27(1):177–237.
- Meira, D., L.G. Woyann, A.H. Bozi, A.S. Milioli, E. Beche, M.C. Panho, L.A. Madella, F. Barriounevo, V.S. Marchioro, and G. Benin. 2020. Asian soybean rust: A scientometric approach of *Phakopsora pachyrhizi* studies. *Euphytica* 216(8):133, doi: <https://doi.org/10.1007/s10681-020-02667-x>.
- Miron, D. and A.A. Schaffer. 1991. Sucrose phosphate synthase, sucrose synthase, and invertase activities in developing fruit of *lycopersicon-esculentum* mill and the sucrose accumulating *lycopersicon-hirsutum* humb and bonpl. *Plant Physiol.* 95(2):623–627, doi: <https://doi.org/10.1104/pp.95.2.623>.
- Raparelli, E. and D. Lolletti. 2020. Research, innovation and development on *Corylus avellana* through the bibliometric approach. *Int. J. Fruit Sci.* 20(Suppl. 3):S1280–S1296, doi: <https://doi.org/10.1080/10583362.2020.1784076>.
- Reyes-Gonzalez, L., C.N. Gonzalez-Brambila, and F. Veloso. 2016. Using coauthorship and citation analysis to identify research groups: A new way to assess performance. *Scientometrics* 108(3):1171–1191, doi: <https://doi.org/10.1007/s11192-016-2029-8>.
- Stopar, K., M. Mackiewicz-Talarczyk, and T. Bartol. 2021. Cotton fiber in Web of Science and Scopus: Mapping and visualization of research topics and publishing patterns. *J. Nat. Fibers* 18(4):547–558, doi: <https://doi.org/10.1080/15440478.2019.1636742>.
- Sun, J. and B.-Z. Yuan. 2021. Trend and research status of Agronomy based on the Essential Science Indicators during 2009–2019. *Agron. J.* 113(2):2184–2194, doi: <https://doi.org/10.1002/agj2.20628>.
- Sun, J. and B.-Z. Yuan. 2019. Visualization analysis of research on rice with fertilizer from the ‘Agronomy’ category based on CiteSpace. *Curr. Sci.* 117(9):1449–1458, doi: <https://doi.org/10.18520/cs/v117/i9/1449-1458>.
- Sun, J. and B.-Z. Yuan. 2020a. Mapping of the world rice research: A bibliometric analysis of top papers during 2008–2018. *Ann. Library Inf. Studies* 67(1):56–66.
- Sun, J. and B.-Z. Yuan. 2020b. Bibliometric mapping of top papers in Library and Information Science based on the Essential Science Indicators Database. *Malays. J. Libr. Inf. Sci.* 25(2):61–76, doi: <https://doi.org/10.22452/mjlis.vol25no2.4>.
- Sun, J. and B.-Z. Yuan. 2020c. Mapping of top papers in the subject category of Water Resources based on the Essential Science Indicators. *Ann. Library Inf. Studies* 67(2):90–102.
- Tang, M., H.C. Liao, Z.J. Wan, E. Herrera-Viedma, and M.A. Rosen. 2018. Ten years of sustainability (2009 to 2018): A bibliometric overview. *Sustainability* 10(5):1655, doi: <https://doi.org/10.3390/su10051655>.
- Tatry, M.V., D. Fournier, B. Jeannequin, and F. Dosba. 2011. Tools for analyzing and mapping scholarly publications not indexed by the Web of Science: The case of fruit and vegetable publications by the French National Institute for Agricultural Research (INRA). *Fruits* 66(2):131–140, doi: <https://doi.org/10.1051/fruits/2011022>.
- Thakur, H., S. Sharma, and M. Thakur. 2019. Recent trends in muskmelon (*Cucumis melo* L.) research: An overview. *J. Hort. Sci. Biotechnol.* 94(4):533–547, doi: <https://doi.org/10.1080/14620316.2018.1561214>.
- Turgeon, R. and S. Wolf. 2009. Phloem transport: Cellular pathways and molecular trafficking. *Annu. Rev. Plant Biol.* 60:207–221, doi: <https://doi.org/10.1146/annurev.arplant.043008.092045>.
- Van Eck, N.J. and L. Waltman. 2010. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84(2):523–538, doi: <https://doi.org/10.1007/s11192-009-0146-3>.
- Velasco-Muñoz, J.F., J.A. Aznar-Sánchez, L.J. Belmonte-Ureña, and M.J. López-Serrano. 2018a. Advances in water use efficiency in agriculture: A bibliometric analysis. *Water* 10(4):377, doi: <https://doi.org/10.3390/w10040377>.
- Velasco-Muñoz, J.F., J.A. Aznar-Sánchez, L.J. Belmonte-Ureña, and I.M. Román-Sánchez. 2018b. Sustainable water use in agriculture: A review of worldwide research. *Sustainability* 10(4):1084, doi: <https://doi.org/10.3390/su10041084>.
- Wambu, E.W. and Y.S. Ho. 2016. A bibliometric analysis of drinking water research in Africa. *Water SA*. 42(4):612–620, doi: <https://doi.org/10.4314/wsa.v42i4.12>.
- Wang, Y.P., W.Z. Liu, G. Li, W.M. Yan, and G.Y. Gao. 2019. A bibliometric analysis of soil and water conservation in the loess tableland-gully region of China. *Water* 11:20, doi: <https://doi.org/10.3390/w11010020>.
- White-Gibson, A., B. O’Neill, D. Cooper, M. Leonard, and B. O’Daly. 2019. Levels of evidence in pelvic trauma: A bibliometric analysis of the top 50 cited papers. *Ir. J. Med. Sci.* 188(1):155–159, doi: <https://doi.org/10.1007/s11845-018-1818-x>.
- Yeung, A.W.K., N.T. Tzvetkov, G. Zengin, D.D. Wang, S.W. Xu, G. Mitrovic, M. Brncic, S. Dall’Acqua, V. Pirgozliev, A. Kijjoo, M.I. Georgiev, and A.G. Atanasov. 2019. The berries on the top. *J. Berry Res.* 9(1):125–139, doi: <https://doi.org/10.3233/JBR-180357>.
- Yuan, B.-Z. and J. Sun. 2019. Bibliometric and mapping of top papers in the subject category of green and sustainable science and technology based on ESI. *COLLNET J. Scientometr. Inf. Manage.* 13(2):269–289, doi: <https://doi.org/10.1080/09737766.2020.1716643>.
- Yuan, B.-Z. and J. Sun. 2020a. Bibliometric analysis of research on the maize based on top papers during 2009–2019. *COLLNET J. Scientometr. Inf. Manage.* 14(1):75–92, doi: <https://doi.org/10.1080/09737766.2020.1787110>.
- Yuan, B.-Z. and J. Sun. 2020b. Mapping the scientific research on maize or corn: A bibliometric analysis of top papers during 2008–2018. *Maydica* 65(2):M17.
- Zhang, J., J.J. Wang, P.C. Wang, and T.T. Guo. 2020. Effect of no-tillage and tillage systems on melon (*Cucumis melo* L.) yield, nutrient uptake and microbial community structures in greenhouse soils. *Folia Hort.* 32(2):265–278, doi: <https://doi.org/10.2478/fhort-2020-0024>.